CMPS 312

Declarative UI using Jetpack Compose

Dr. Abdelkarim Erradi

CSE@QU

Outline

1. Jetpack Compose Key Concepts
2. UI Components
3. Layouts
4. Modifiers
5. State

Jetpack Compose Key Concepts

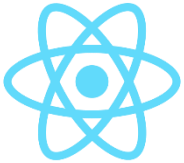
https://developer.android.com/jetpack/compose/mental-model

Declarative UI is a major trend

- Describe WHAT to see NOT HOW

Flutter: Google's UI toolkit for building natively compiled applications for mobile, web and desktop from a single codebase

SwiftUI: Apple’s new declarative framework for creating apps that run on iOS



React: A JavaScript library for building user interfaces

Jetpack Compose: a **modern toolkit** for building native Android UI (released July 2021)

Jetpack Compose

- Jetpack Compose is a **modern UI toolkit** for Android
  - It simplifies UI development with less code and intuitive Kotlin APIs that follow best practices
- A **declarative component-based programming model**
  - UI is built using composable functions
    - Each function define a piece the app's UI programmatically by **describing WHAT to see** (layout/ look and feel) **NOT HOW**
    - Compiler takes care of the HOW and constructs UI elements
  - As state changes the UI automatically updates (Reactive UI)

  (without imperatively mutating UI views)
- Inspired by/similar to other declarative UI frameworks such as React and Flutter

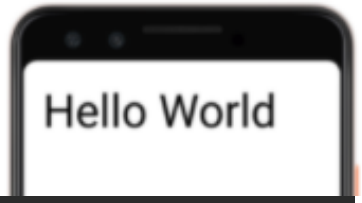
How to define a piece of UI?

- UI is **composed** of small reusable **components**
- UI Component = Composable **function**:
  - Just a function annotated with **@Composable**
  - Takes some inputs and emits a piece of UI
  - Composable converts the state (i.e., app data) into UI

  - **UI = f(state) : UI is a visual representation of state**
    (e.g., display a tweet and associated comments)
  - **State changes trigger automatic update of the UI**

UI as a function

String → `fun Greeting(name: String) = println("Hello, $name")` → stdout

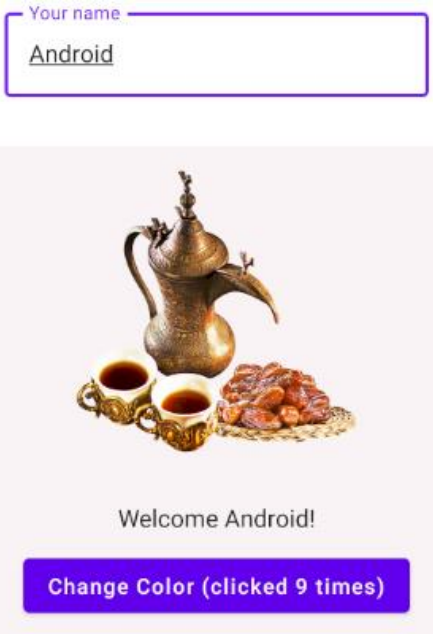


Mark as a composable

Data → `@Composable fun Greeting(name: String) = Text("Hello, $name")` → UI

Greeting function uses the input data to render a Text widget on the screen

UI = Composition of UI functions



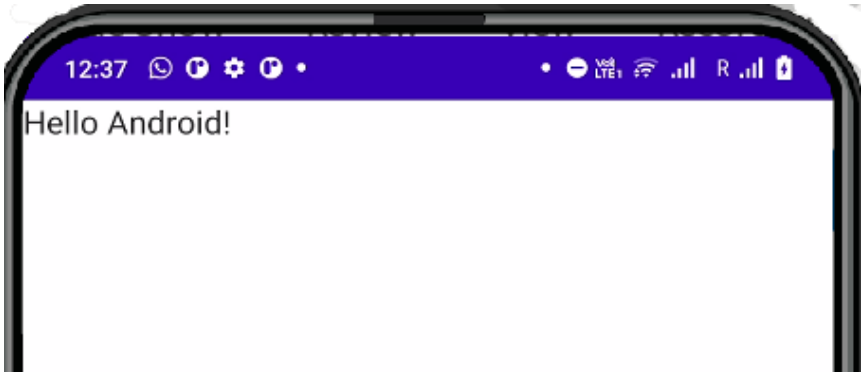
- The top-level composable function describes the UI by calling other composables and passing them the appropriate data

```
@Composable
fun WelcomeScreen() {
    var userName by remember { mutableStateOf( value: "Android") }
    Column { this: ColumnScope
        NameEditor(name = userName, nameChange = { newName -> userName = newName })
        Welcome(userName)
    }
}

@Composable
fun NameEditor(name: String, nameChange: (String) -> Unit) {...}

@Composable
fun Welcome(name: String) {...}
```

App Entry Point

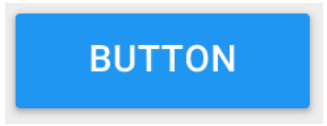
- When the app launches it creates and starts the ***Main Activity*** *(specified in AndroidManifest.xml)*
- The **Activity** acts as a container to load the UI **main screen** using **setContent** in the **onCreate** method
  - Modern apps have **1 activity** several and composables that get loaded on-demand ad the using interacts with the App

```
class MainActivity : ComponentActivity() {
    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        setContent {
            Greeting("Android")
        }
    }
}
@Composable
fun Greeting(name: String) {
    Text(text = "Hello $name!")
}
```

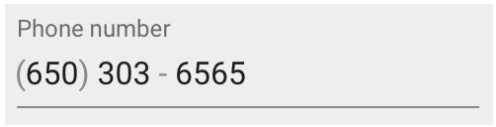


UI Components

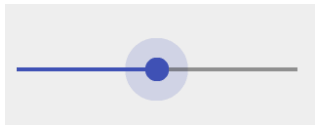
Button



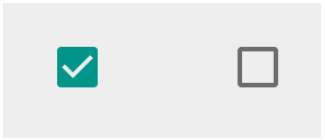
TextField



Slider

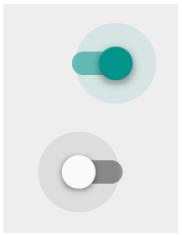


CheckBox



RadioButton

Switch



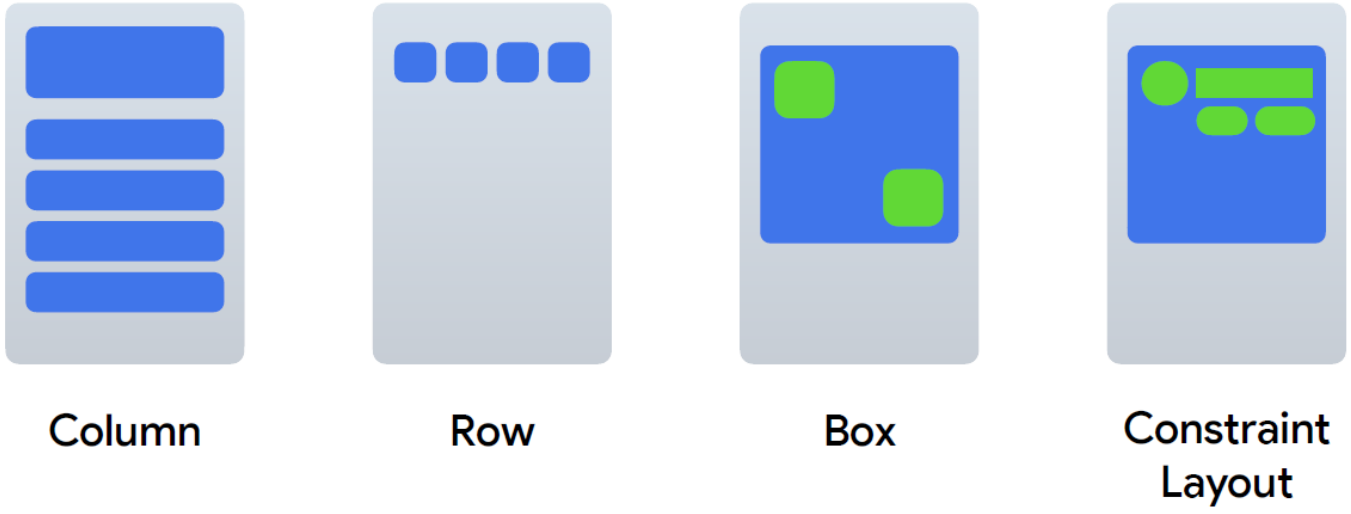
See more details in slides
'05 UI Components-Layouts'

Back

Full list available at this link

Layouts

- Use a Layout to **position** UI elements on the screen
- **`Row`** - position elements horizontally
- **`Column`** - position elements vertically
- **`Box`** - position elements in the corners of the screen or stack them on top of each other
- Use Constraint Layout (self-study) for complex layouts



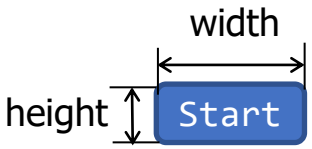
See more details in slides '05 UI Components-Layouts'

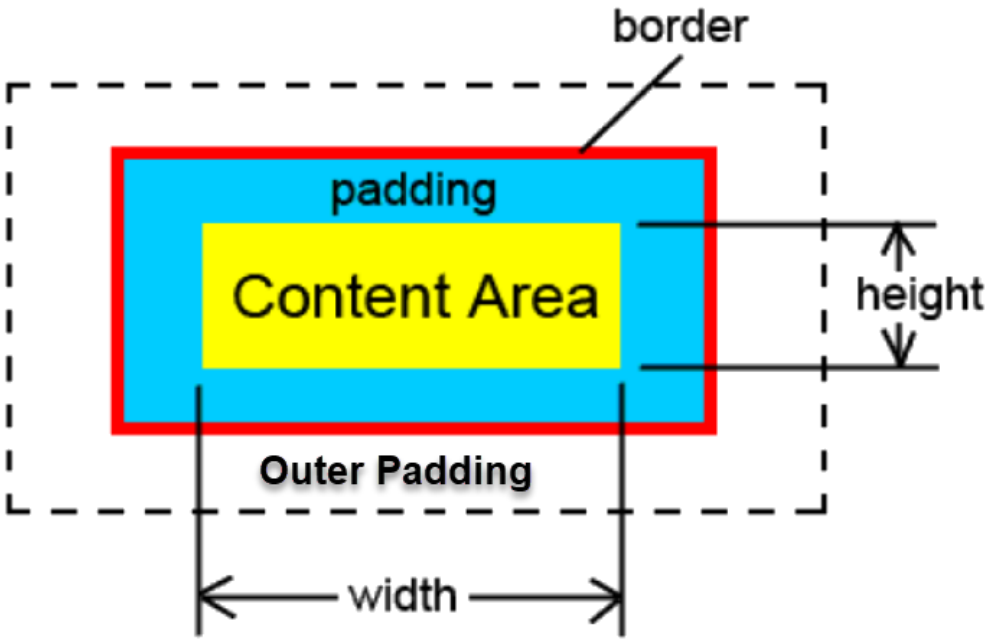
Modifiers

Modifiers

- Modifiers are used to configure and customize the style (i.e., the look) or behavior of UI components
  - **Style** UI element such as setting the size, color, border, padding, and layout parameters to control spacing and positioning
  - **Add behavior** to UI elements such as making the element clickable or scrollable
- Several modifiers can be **chained**
  - Each modifier **modifies** the composable and **prepares** it for the next modifier in the chain
  - The **order of modifiers** in the chain matters

Size and Spacing





- Composable size and spacing properties can be set using **Modifiers**:
  - **Outer padding** (aka margin) - the space that separates composables
  - **Border** - the line around each edge of the composable
  - **Padding** - the space between the border and the content

Size and Spacing - Example

```
Text(
    text = "Width and Height",
    color = Color.White,
    modifier = Modifier
        .padding(10.dp) // Outer padding (margin)
        .background(Color.Blue)
        .width(200.dp)
        .height(150.dp)
//.size(width = 250.dp, height = 100.dp) //Alternative way
)
```

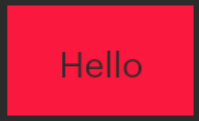

```
Text(
    text = "Padding and margin!",
    modifier =
        Modifier.padding(16.dp) // Outer padding (margin)
                .background(color = Color.Yellow) //background color
                .border(
                    width = 2.dp,
                    color = Color.Gray
                ) // Add a border
                .padding(8.dp) // Inner padding
)
```

Modifiers Chain

- Modifiers can be chained and the order matters!
  - Applied in a sequential way and the order impacts the behavior

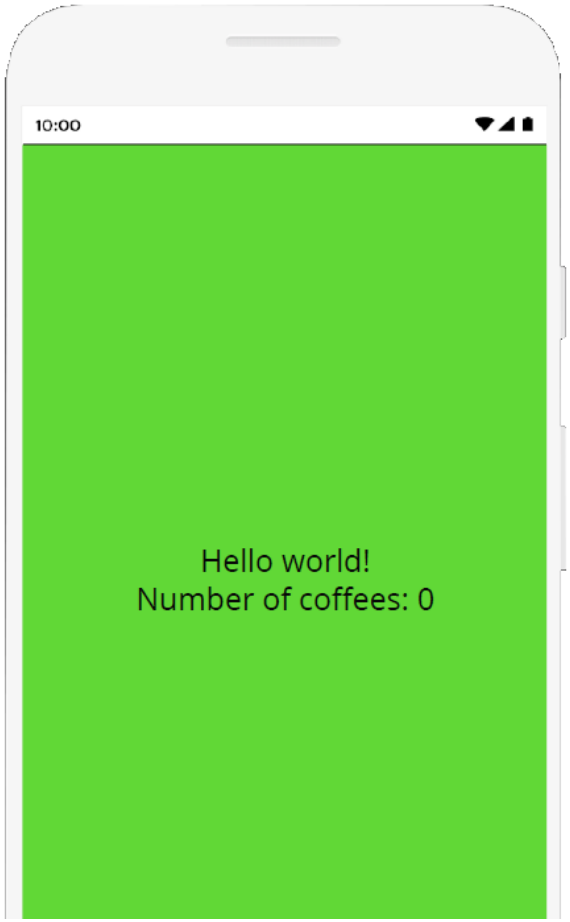
```
Text(
    text = "Hello",
    modifier = Modifier.padding(16.dp)
        .background(color = Color.Red)
)
```


```
Text(
    text = "Hello",
    modifier = Modifier.background(color = Color.Red)
        .padding(16.dp)
)
```

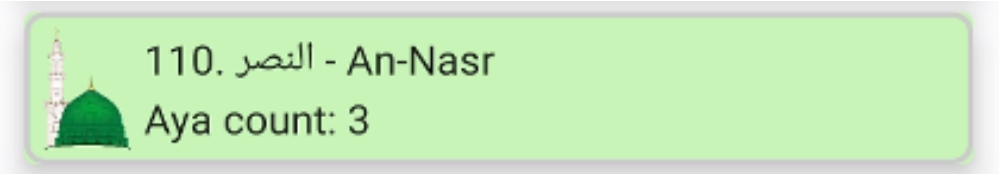


Another Modifier Example

```
@Composable                                                    Kt
fun Greeting(name: String) {
  Column(
    modifier = Modifier.fillMaxSize()
                       .background(Color.Green)
                       .padding(16.dp),
    horizontalAlignment = Alignment.CenterHorizontally,
    verticalArrangement = Arrangement.Center
  ){
    Text(text = "Hello $name!")
    Text(text = "Number of coffees: 0")
  }
}
```



Surah Card




```
@Composable
fun SurahCard(surah: Surah) {
    Card (elevation = 10.dp,
        backgroundColor = if (surah.type == "Medinan") lightGreen else lightYellow,
        modifier = Modifier
            .fillMaxWidth()
            .padding(horizontal = 5.dp)
            .border(width = 2.dp, color = Color.LightGray, shape = RoundedCornerShape(8.dp))
    ) {
        Row (verticalAlignment = Alignment.CenterVertically,
            horizontalArrangement = Arrangement.spacedBy(4.dp),
            modifier = Modifier.padding(5.dp)
        ) {
            val imgResourceId = if (surah.type == "Medinan") R.drawable.ic_madina
                                else R.drawable.ic_mecca
            Image(painter = painterResource(id = imgResourceId),
                  contentDescription = "Surah Type",
                  Modifier.height(50.dp)
            )
            Column(verticalArrangement = Arrangement.spacedBy(2.dp)) {
                Text(text = "${surah.id}. ${surah.name} - ${surah.englishName}")
                Text(text = "Aya count: ${surah.ayaCount}")
            }
        }
    }
```

Modifier.clickable

```
Text(
    text = "+",
    modifier = Modifier
        .border(2.dp, Color.Gray)
        .padding(10.dp)
        .clickable {
            count += 1
        },
    style = MaterialTheme.typography.h5
)
```

State

https://developer.android.com/jetpack/compose/state

State

- State = any value that can change overtime
- State variable must be declared as **Mutable State** variables to act as **Change Notifiers**
  - They **are observed** by the Jetpack compose runtime
  - Any change of a state variable will trigger the **recomposition** of any composable functions that **reads** the state variable

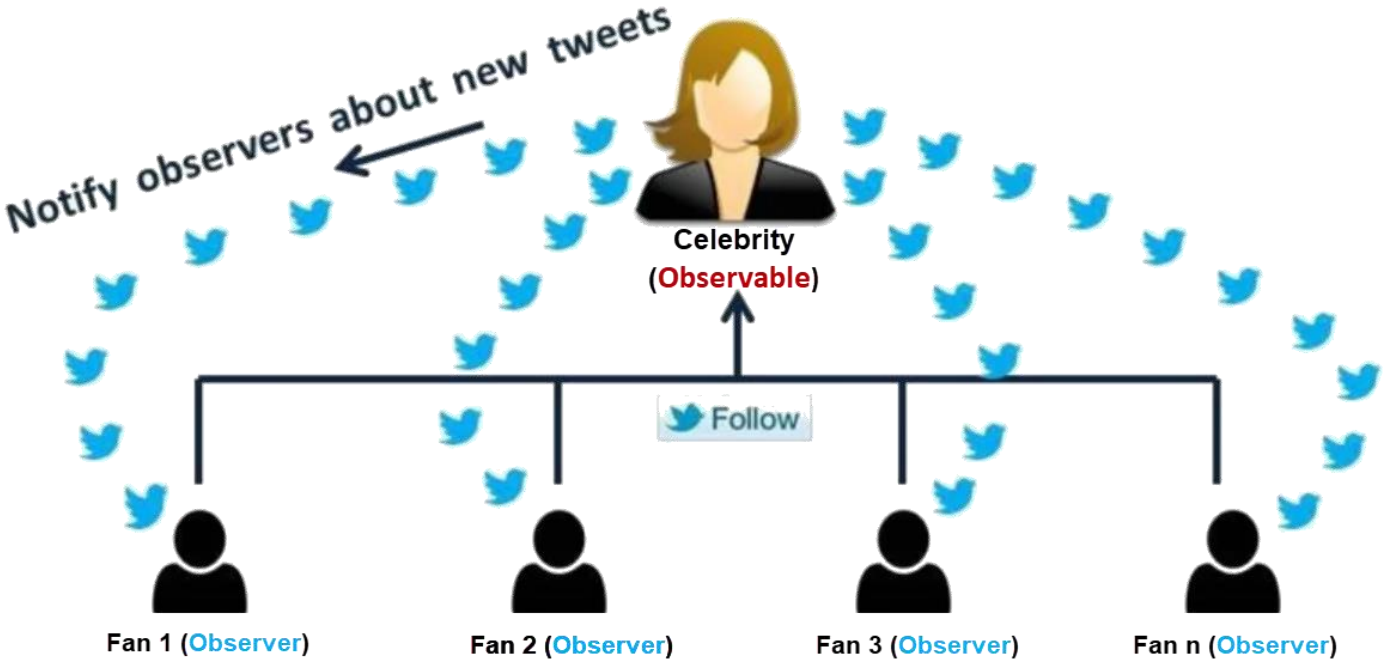
=> UI is **auto-updated** to reflect the updated app state

```
var stateVar by remember { mutableStateOf(defaultVal) }
```

- **remember** is used to **store** values of state variable in the composition tree (to preserve the values and avoid reinitialization to the default value during the recomposition)
  - the stored value is returned during recomposition

Observer Pattern at the heart of Jetpack Compose

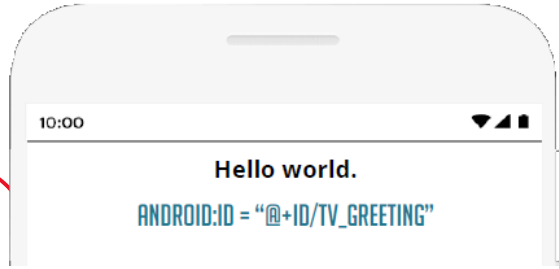
- Observer Pattern Real-Life Example: A celebrity who has many fans on Tweeter
  - Fans want to get all the latest updates (posts and photos)
  - Here fans are **Observers** and celebrity is an **Observable** (analogous **Mutable State** in Jetpack Compose)
  - **Mutable State** is an **observable data holder**: Jetpack Compose runtime **observes its changes** and updates the UI accordingly



Imperative UI vs. Declarative UI

- Imperative UI – call a setter on the view to change its internal state

```
TextView greetings = (TextView) findViewById(R.id.tv_greeting)
greetings.text = "Hello world."
```



- UI in Compose is immutable
  - In compose you cannot access/update UI elements directly (as done in the imperative approach)
  - The only way to update the UI is by updating the state variable(s) used by the UI elements – this triggers automatic UI update
    - E.g., displayed ***greeting text*** can only be changed by updating the ***name*** state variable

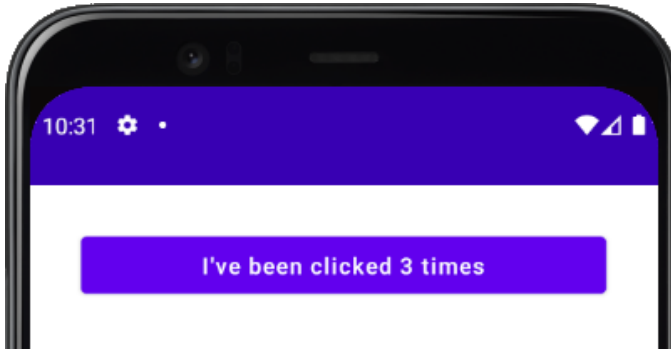
```
@Composable
fun WelcomeScreen() {
    var name by remember { mutableStateOf("Android") }
    Greeting(name)
}
```

```
@Composable
fun Greeting(name: String) {
  Text(text = "Hello $name!")
}
```

Recomposition

- When the user interacts with the UI, the UI raises events such as onClick
  - Those events should notify the app logic, which can then change the app's state
  - When the state changes it causes the composable functions to be automatically called again with the new data => this causes the UI elements to be redrawn
  - This process is called **recomposition**
- The Compose framework can intelligently recompose only the components that changed

Recomposition Example

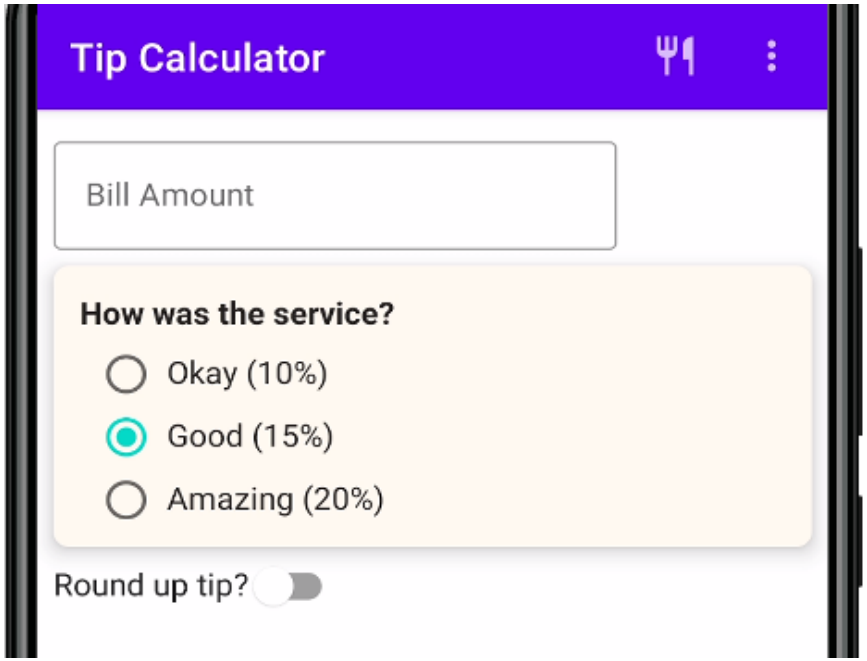


- Every time the button is clicked, the UI raises ***onClick*** event to notify the app logic, which increments **clicksCount** state variable
- This causes a **recomposition** to take place, i.e., the **ClickCounter** function is automatically called again to redrawn the Button

```
@Composable
fun MainScreen() {
    var clicksCount by remember { mutableStateOf(0) }
    ClickCounter(clicks = clicksCount, onClick = { clicksCount += 1 })
}
@Composable
fun ClickCounter(clicks: Int, onClick: () -> Unit) {
    Button(onClick = onClick) {
        Text("I've been clicked $clicks times")
    }
}
```

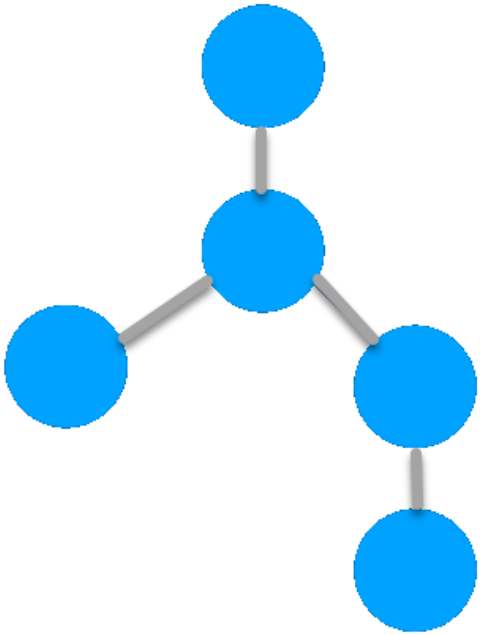
Tip Calculator Example

- In the example below, notice no Compute/OK button, any change of input auto-recomputes and re-displays the tip value
  - Like Excel way: changing a cell value triggers auto-update of formulas and graphs referencing it
- Plus, the code is much more concise and elegant (see posted example)



How recomposition works

1. Creates an abstract representation of the UI and renders it
2. When a change occurs, it creates a new representation
3. Computes the differences between the two representations
4. Renders the differences [if any]



For more details about Jetpack Compose Runtime, watch this video

Stateful versus Stateless

- A stateful composable uses **remember** to store an object in the composition tree
  - However, stateful composable tend to be less reusable and harder to test
- A stateless composable that doesn't hold any state
  - The caller controls and manages the state
  - An easy way to achieve stateless is by using **state hoisting**

State Hoisting

- To make a composable stateless, **extract** its state and **move it to the caller** of the composable
- Then pass the state to the composable as an immutable parameter, along with a callback function that the composable can call to update that state in response to events (e.g., onValueChange, onExpand and onCollapse) e.g.,
  - `name: String` - the current value to display
  - `onNameChange: (String) -> Unit` - a callback that requests the value to change
- Hoisted state variables are owned by the Caller and can passed to other composables

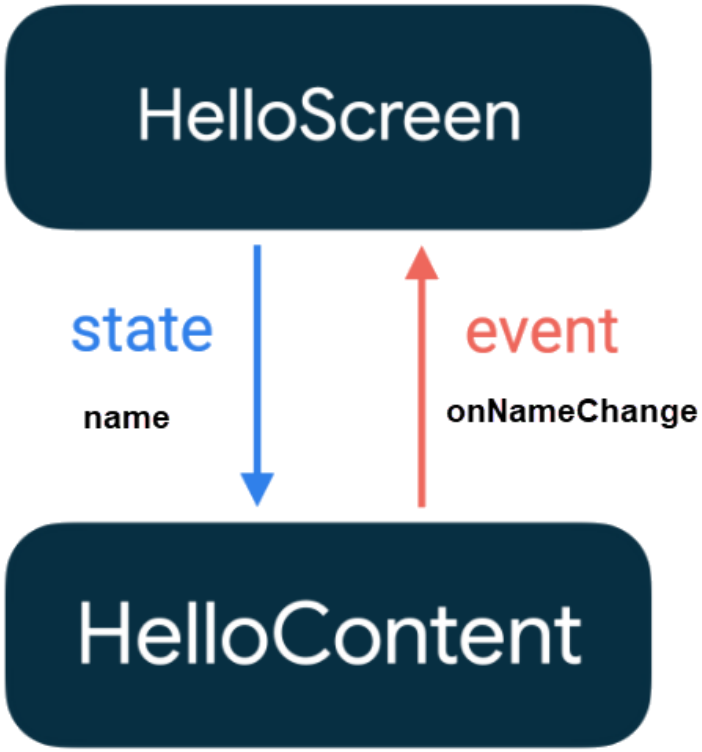
State Hoisting - Example

```
@Composable
fun HelloScreen() {
    var name by remember { mutableStateOf("") }

    HelloContent(name = name, onNameChange = { name = it })
}

@Composable
fun HelloContent(name: String, onNameChange: (String) -> Unit) {
    Column(modifier = Modifier.padding(16.dp)) {
        Text(
            text = "Hello, $name",
            modifier = Modifier.padding(bottom = 8.dp),
            style = MaterialTheme.typography.h5
        )
        OutlinedTextField(
            value = name,
            onValueChange = onNameChange,
            label = { Text("Name") }
        )
    }
}
```

Unidirectional Data Flow

= a design where **state flows down and events flow up**

```
var name by remember { mutableStateOf("") }
HelloContent(name = name, onNameChange = { name = it })
```



State flows down via function parameter

(e.g., *name*)

(State change) Event flows up via callback function

(e.g., *onNameChange*)

By hoisting the state out of HelloContent, it can be **reused** in different situations, and it is easier to test

Summary

- Declarative UI is the trend for UI development
- UI is composed of small reusable components
- UI Component = Composable function
  - just a function annotated with `@Composable`
- Layouts are used to position UI elements on the screen
- UI in Compose is **immutable**
  - It only accepts state & exposes events
  - **Unidirectional Data Flow** pattern:
    - State flows down via parameters
    - Events flow up via callbacks
- .. mastering Compose will take some time and practice  ...

Resources

- Jetpack compose tutorial

https://developer.android.com/jetpack/compose/tutorial

- Jetpack compose Code Labs

https://developer.android.com/courses/pathways/compose

- Jetpack Compose Playground - UI component examples

https://foso.github.io/Jetpack-Compose-Playground/

https://github.com/Foso/Jetpack-Compose-Playground

https://github.com/Gurupreet/ComposeCookBook

- Compose Samples

https://github.com/android/compose-samples